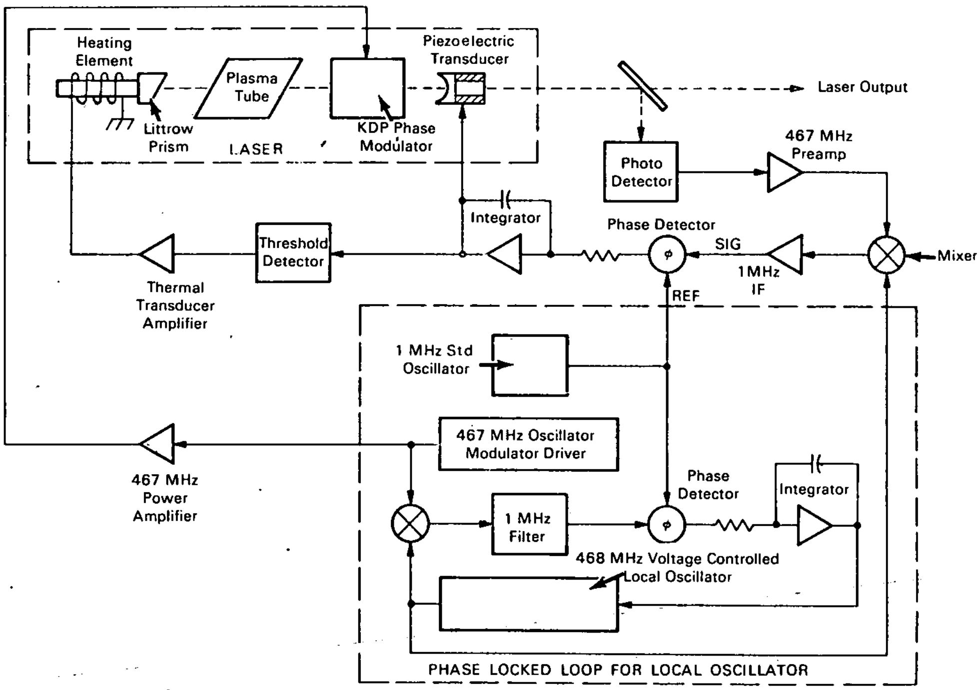
NASA TECH BRIEF

Active Frequency Control System for Argon FM Laser



The primary function of the frequency control system is to position the mirrors at either end of the laser cavity so that the mirror separation is independent of thermal and acoustical fluctuations. This condition is achieved by splitting a small portion of the laser output (10 microwatts) and directing it upon a photodetector (photodiode). The narrowband preamplifier centered at 467 MHz then amplifies this signal by 26 dB, with an 8 dB noise figure. The noise figure of the control loop is thus established, and the detected signal has sufficient power to be down-converted to 1 MHz in the mixer. The signal from the mixer is passed onto the 1 MHz IF amplifier, where the bulk of the system loop gain is realized. The bandpass characteristics of the 400 kHz bandwidth IF amplifier are important in that any phase or amplitude distortion in the detected signal will cause instabilities in the loop compensation system. It was for this reason that a "maximumly flat" characteristic was chosen.

The output of the IF amplifier is compared with a 1 MHz standard oscillator, which yields the phase information as to which direction the piezoelectric

(continued overleaf)

transducer must move in order to compensate for any fluctuations in cavity length. The amplitude of this error signal determines the rate of compensation. An integrator is used between the phase-sensitive detector and the control elements, to convert the entire loop to a first-order system with no net dc positional error.

In order for the system to function correctly, three sinusoidal drive signals are required. The first signal is the 467 MHz modulator drive signal. This signal is supplied to a power amplifier which provides one to three watts of power to the KDP (potassium dihydrogen phosphate) phase modulator used to couple laser modes.

Since the change in phase of the 467 MHz beat signal from the FM laser produces the discriminant which operates the entire loop, the detected signal must be heterodyned down to a lower frequency, while preserving all the phase information. The heterodyning is accomplished by phase locking the 468 MHz voltage-controlled local oscillator to the 467 MHz modulator drive via a 1 MHz standard oscillator. As a result, regardless of the precise frequency to which the modulator drive is tuned, the local oscillator signal is offset by 1 MHz, and the difference between these is precisely fixed in phase with respect to the 1 MHz standard. Therefore, as the optical cavity drifts thermally or acoustically, the change in phase of the 467 MHz beat signal will be detected by the preamplifier and IF amplifier, and will then form the discriminant in the phase detector.

As a result of the phase information inherent in the FM discriminant, the error signal is always of the correct sign. Thus the system acquires lock automatically; and if lock should be lost, it is reestablished without manual intervention.

One of the problems inherent in the stabilization of lasers is that the amount of thermal expansion in the laser cavity can be many optical half-wavelengths. The piezoelectric transducer, however, can move through only two or three half-wavelengths with maximum voltage applied. In order to compensate for the slow thermal drifts in the length of the laser cavity, a thermal transducer was placed behind one of the laser mirrors as shown in the diagram. This transducer is simply an aluminum spool wound with heating wire. When the voltage applied to the piezoelectric transducer begins to exceed the designated range, the transducer amplifier drives current into the heating element, which in turn compensates for expansion and contraction of the laser cavity. This also has the effect of keeping the integrator dc level constant at approximately 100 volts. The thermal transducer can move the laser mirror through 80 half-wavelengths, and it has a time constant of about 5 seconds. The water flow through the base plate of the laser is adjusted to reduce its thermal drift in order to keep the current levels in the transducer at reasonable values.

Notes:

Documentation is available from:

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